

What Causes Climate?

Objectives

After this lesson, students will be able to

I.4.1.1 Identify factors that influence temperature and precipitation.

I.4.1.2 Explain what causes the seasons.

Target Reading Skill

Building Vocabulary Explain that knowing the definitions of key-concept words helps students understand what they read.

Answers

As students read each passage that contains a key term, encourage them to write its definition in their own words. Invite students to share their definitions.

Preteach

Build Background Knowledge

What Is Climate?

Ask: What is the weather like today? Is today's weather typical of the weather we usually have at this time of year? (Accept all answers without comment.) Tell students that they will learn how climate differs from weather and what causes climate.

What Causes Climate?

Reading Preview

Key Concepts

- What factors influence temperature?
- What factors influence precipitation?
- What causes the seasons?

Key Terms

- climate • microclimate
- tropical zone • polar zone
- temperate zone
- marine climate
- continental climate
- windward • leeward
- monsoon

Target Reading Skill

Building Vocabulary After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a meaningful sentence using each Key Term.

An oasis in the Mojave Desert ▼



Discover Activity

How Does Latitude Affect Climate?

1. On a globe, tape a strip of paper from the equator to the North Pole. Divide the tape into three equal parts. Label the top section *poles*, the bottom section *equator*, and the middle section *mid-latitudes*.
2. Tape the end of an empty toilet paper roll to the end of a flashlight. Hold the flashlight about 30 cm from the equator. Turn on the flashlight to represent the sun. On the paper strip, have a partner draw the area the light shines on.
3. Move the flashlight up slightly to aim at the "mid-latitudes." Keep the flashlight horizontal and at the same distance from the globe. Again, draw the lighted area.
4. Repeat Step 3, but this time aim the light at the "poles."



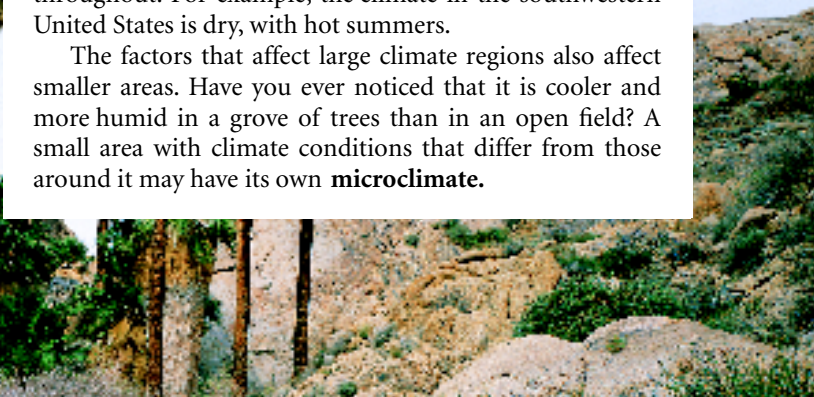
Think It Over

Observing How does the size of the illuminated area change? Do you think the sun's rays heat Earth's surface evenly?

The weather in an area changes every day. At a given location, the weather may be cloudy and rainy one day and clear and sunny the next. **Climate**, on the other hand, refers to the average, year-after-year conditions of temperature, precipitation, winds, and clouds in an area. For example, California's Mojave Desert, shown below, has a hot, dry climate.

Scientists use two main factors—precipitation and temperature—to describe the climate of a region. A climate region is a large area that has similar climate conditions throughout. For example, the climate in the southwestern United States is dry, with hot summers.

The factors that affect large climate regions also affect smaller areas. Have you ever noticed that it is cooler and more humid in a grove of trees than in an open field? A small area with climate conditions that differ from those around it may have its own **microclimate**.



Discover Activity

Skills Focus Observing

Materials Globe, cash register or adding machine paper, clear tape, pencil, flashlight, empty toilet paper roll, metric ruler

Time 15 minutes

Tips Before starting this activity, cut the paper into lengths that are slightly longer than the distance between the equator and the North Pole on the globe. Have students label the paper before they tape it to the globe. One student holds the flashlight at the same distance from the globe but moves it up in a straight line perpendicular to the globe for each drawing.

Expected Outcome The shapes will change from a perfect circle at the equator to an elongated oval at the North Pole.

Think It Over The shape is a perfect circle at the equator, an oval at the mid-latitudes, and an elongated, faded oval at the poles. The sun's rays heat Earth unevenly because the light rays from the sun strike Earth's surface at different angles.

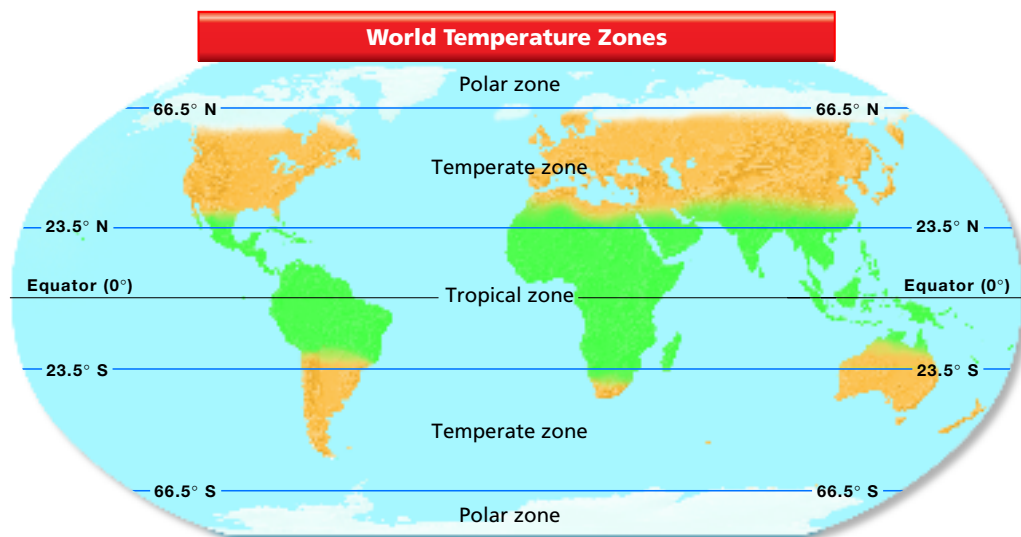


FIGURE 1
The tropical zone has the warmest climates. Cold climates occur in the polar zone. In between lies the temperate zone, where climates vary from warm to cool.
Interpreting Maps In which temperature zone is most of the United States located?

Factors Affecting Temperature

Why are some places warm and others cold? **The main factors that influence temperature are latitude, altitude, distance from large bodies of water, and ocean currents.**

Latitude In general, climates of locations near the equator are warmer than climates of areas far from the equator. The reason is that the sun's rays hit Earth's surface most directly at the equator. At the poles, the same amount of solar radiation is spread over a larger area, and therefore brings less warmth.

Recall that latitude is the distance from the equator, measured in degrees. Based on latitude, Earth's surface can be divided into the three temperature zones shown in Figure 1. The **tropical zone** is the area near the equator, between about 23.5° north latitude and 23.5° south latitude. The tropical zone receives direct or nearly direct sunlight all year round, making climates there warm.

In contrast, the sun's rays always strike at a lower angle near the North and South poles. As a result, the areas near both poles have cold climates. These **polar zones** extend from about 66.5° to 90° north and 66.5° to 90° south latitudes.

Between the tropical zones and the polar zones are the **temperate zones**. In summer, the sun's rays strike the temperate zones more directly. In winter, the sun's rays strike at a lower angle. As a result, the weather in the temperate zones ranges from warm or hot in summer to cool or cold in winter.

Instruct

Factors Affecting Temperature

Teach Key Concepts

L2

How Latitude Affects Temperature

Focus Ask: What does latitude measure? (The distance of a point from the equator, measured in degrees)

Teach Instruct students to find the equator in Figure 1. Then ask: **At what degree of latitude is the North Pole?** (90° north latitude) Point out the three temperature zones on the map. Ask: **Why is the tropical zone the warmest temperature zone, and why is the polar zone the coldest?** (The tropical zone receives direct or nearly direct sunlight all year round; the sun's rays strike at a lower angle at the poles.)

Apply Have students identify countries or continents in each temperature zone, and infer what yearly temperatures are like in these areas. **learning modality: visual**

Help Students Read

L1

Identifying Main Ideas Have students read the main topic sentence on this page. Ask: **What are the main ideas to look for in this section?** (How latitude, altitude, distance from large bodies of water, and ocean currents affect temperature). As students read, have them write on index cards brief explanations of how these factors affect temperature.

Independent Practice

L2

All in One Teaching Resources

- [Guided Reading and Study Worksheet: What Causes Climate?](#)
- [Transparency I39](#)

Student Edition on Audio CD

Differentiated Instruction

Gifted and Talented

L3

Culture and Climate Students can learn how climate affects the culture of a group of people by comparing and contrasting types of clothing, housing, and customs of people living in different temperature zones. Encourage students to choose a group of people to study. They may choose native cultures or modern

cultures from around the world or from different areas of the United States. Monitor the choices so that each student or group is studying a different culture. Challenge students to find creative ways to present the culture of the people they have studied. **learning modality: verbal**

Monitor Progress

L2

Drawing Instruct students to make a diagram that shows the different angles at which the sun's rays strike Earth in each temperature zone. Students may place their drawings in their portfolios.



Answer

Figure 1 The temperate zone

Air Temperature and Altitude

Materials small black mat, desk lamp with high-intensity bulb, 2 thermometers, 2 ring stands with clamps for thermometers

Time 15–20 minutes

Focus Tell students that in this demonstration, the light represents the sun and the mat represents Earth.

Teach Shine the light directly on the black mat for 10 minutes. During this time, set up the ring stands so that one stand holds the bulb of one thermometer 5 cm above the mat and the other stand holds the bulb of the other thermometer 20 cm above the mat. Read the thermometers immediately and then every minute until the temperature stops rising. Encourage students to infer why the thermometer at 5 cm above the mat has a higher temperature reading than the thermometer at 20 cm above the mat. (*The black mat absorbed energy from the light and then radiated the heat into the air above it.*)

Apply Ask: **How is this model similar to what happens on Earth?** (*Air close to the ground is warmed by heat radiated from Earth, just as air closer to the mat was warmed by heat radiated from the mat.*) **learning modality: visual**



FIGURE 2

Effect of Altitude

Mount Kilimanjaro, in Tanzania, is near the equator.

Relating Cause and Effect *What factor is responsible for the difference between the climate at the mountaintop and the climate at the base?*

Altitude The peak of Mount Kilimanjaro towers high above the plains of East Africa. Kilimanjaro is covered in snow all year round, as shown in Figure 2. Yet it is located near the equator, at 3° south latitude. Why is Mount Kilimanjaro so cold?

In the case of high mountains, altitude is a more important climate factor than latitude. In the troposphere, temperature decreases about 6.5 Celsius degrees for every 1-kilometer increase in altitude. As a result, highland areas everywhere have cool climates, no matter what their latitude. At nearly 6 kilometers, the air at the top of Kilimanjaro is about 39 Celsius degrees colder than the air at sea level at the same latitude.

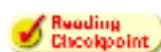
Distance From Large Bodies of Water Oceans or large lakes can also affect temperatures. Oceans greatly moderate, or make less extreme, the temperatures of nearby land. Water heats up more slowly than land. It also cools down more slowly. Therefore, winds off the ocean often prevent extremes of hot and cold in coastal regions. Much of the west coasts of North America, South America, and Europe have mild **marine climates**, with relatively mild winters and cool summers.

The centers of North America and Asia are too far inland to be warmed or cooled by the ocean. Most of Canada and of Russia, as well as the central United States, have continental climates. **Continental climates** have more extreme temperatures than marine climates. Winters are cold, while summers are warm or hot.

Ocean Currents Marine climates are influenced by ocean currents, streams of water within the oceans that move in regular patterns. Some warm ocean currents move from the tropics towards the poles. This affects climate as the warm ocean water warms the air above it. The warmed air then moves over nearby land. In the same way, cold currents bring cold water from the polar zones toward the equator. A cold current brings cool air.

As you read about the following currents, trace their paths on the map in Figure 3. The best-known warm-water current is the Gulf Stream. The Gulf Stream begins in the Gulf of Mexico, then flows north along the east coast of the United States. When it crosses the North Atlantic, it becomes the North Atlantic Drift. This warm current brings mild, humid air to Ireland and southern England. As a result, these areas have a mild, wet climate despite their relatively high latitude.

In contrast, the cool California Current flows southward down the West Coast of the United States. The California Current makes climates along the West Coast cooler than you would expect at those latitudes.



What effect do oceans have on the temperatures of nearby land areas?

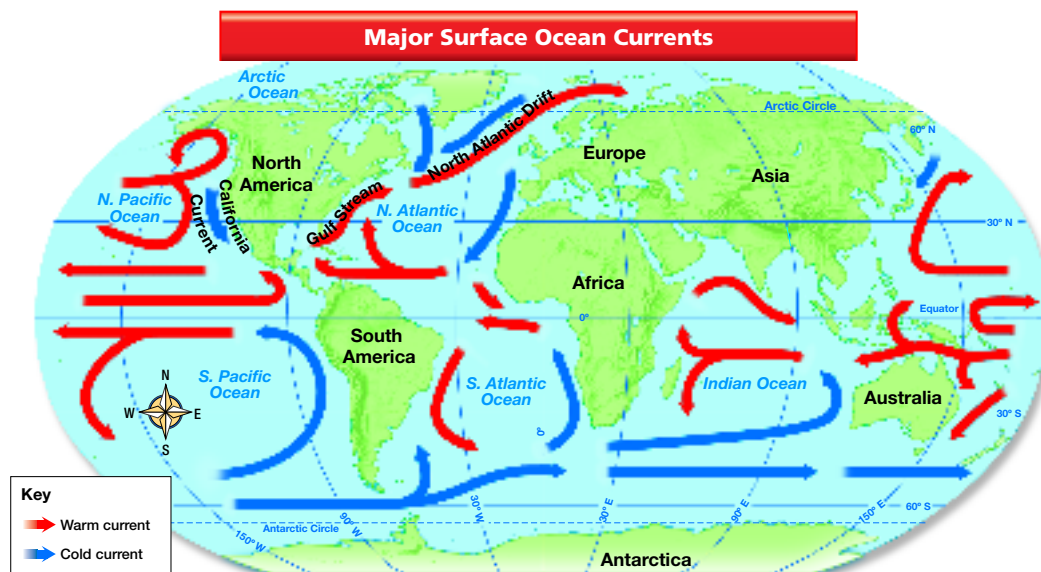
Lab zone Skills Activity

Inferring

Look at the currents in the South Pacific, South Atlantic, and Indian oceans. What pattern can you observe? Now compare currents in the South Atlantic to those in the North Atlantic. What might be responsible for differences in the current patterns?

FIGURE 3

On this map, warm currents are shown in red and cold currents in blue. **Interpreting Maps** What type of current occurs around Antarctica?



Lab zone Build Inquiry

Comparing Water and Soil

L2

Materials 2 small coffee cans, 2 thermometers, 2 ring stands with clamps, refrigerator, soil, water

Time 1 day to prepare, 1 period to observe

Focus Challenge students to predict whether soil or water will warm faster. Tell them that they will test their predictions during this activity.

Teach Have students mostly fill one coffee can with potting soil and mostly fill a second coffee can with water. Students should place both coffee cans in the refrigerator overnight. On the next day, ask students to remove the coffee cans and set them on a lab table. Using the ring stands and clamps, students should suspend one thermometer in the water and the other thermometer in the soil. Have students record the temperature in each can at regular time intervals.

Apply Ask: **Why are coastal areas often cooler on a hot, summer day?** (The water is comparatively cool, and it cools nearby air that can blow over the land.)

All in One Teaching Resources

- [Transparency I40](#)

Lab zone Skills Activity

Skills Focus Inferring

Materials map in text

Time 10 minutes

Tips Tell students to compare both the temperature and direction of the currents.

Expected Outcome Students will notice that the currents in the South Pacific, South Atlantic, and Indian Oceans rotate

L2

in a counterclockwise direction. Currents in the North Atlantic rotate in a clockwise direction. The current patterns differ because the Coriolis effect turns currents to the right north of the equator and to the left south of it.

Extend Challenge students to identify warm currents and cold currents in both hemispheres. **learning modality: visual**

Monitor Progress

L1

Writing Have each student write a paragraph that explains how temperature is affected by altitude, distance from large bodies of water, and ocean currents.

Answers

Figure 2 Altitude

Figure 3 A cold current



In general, oceans moderate the temperatures of nearby land. Ocean currents may also warm or cool the air above them, affecting the temperatures of nearby land when the air moves over it.

Factors Affecting Precipitation

Teach Key Concepts

L2

Rain Shadow Effect

Focus Ask: What happens to air when it rises? (*It cools.*) How does this affect the amount of water that air can hold? (*It lowers it.*) Tell students that sinking air does the opposite—it warms. Ask: How does this affect the amount of water the air can hold? (*It increases it.*)

Teach Review the circumstance of air rising to pass over a mountain range and then sinking on the other side. Ask: Where would air cool and the relative humidity rise? (*On the windward side*) Where would air warm and have a lower relative humidity? (*On the leeward side*)

Apply Ask: Why do dry conditions exist east of the Sierra Nevada Mountains? (*The air loses much of its moisture as it climbs up the westward side of the mountains.*)

learning modality: visual

Help Students Read

L1

Visualizing Instruct students to close their books so that they cannot examine Figure 4. Slowly read aloud the passage about mountain ranges so that students have time to form mental images of the processes you are describing. Then have students open their books to see how the diagram compares with their mental images.

All in One Teaching Resources

- [Transparency I41](#)

Factors Affecting Precipitation

The air masses that pass over an area may bring rain or snow. The amount of precipitation varies from year to year. But over time, total precipitation tends toward a yearly average. What determines the amount of precipitation an area receives? The main factors that affect precipitation are prevailing winds, the presence of mountains, and seasonal winds.

Prevailing Winds As you know, weather patterns depend on the movement of huge air masses. Air masses are moved from place to place by prevailing winds, the directional winds that usually blow in a region. Air masses can be warm or cool, dry or humid. The amount of water vapor in the air mass influences how much rain or snow will fall.

The amount of water vapor in prevailing winds also depends on where the winds come from. Winds that blow inland from oceans or large lakes carry more water vapor than winds that blow from over land. For example, winter winds generally blow from west to east across the Great Lakes. The winds pick up moisture that evaporates from the lakes. As a result, areas that are downwind can receive large amounts of snow.

Mountain Ranges A mountain range in the path of prevailing winds can also influence where precipitation falls. When humid winds blow from the ocean toward coastal mountains, they are forced to rise, as shown in Figure 4. The rising air cools and its water vapor condenses, forming clouds. Rain or snow falls on the **windward** side of the mountains, the side the wind hits.

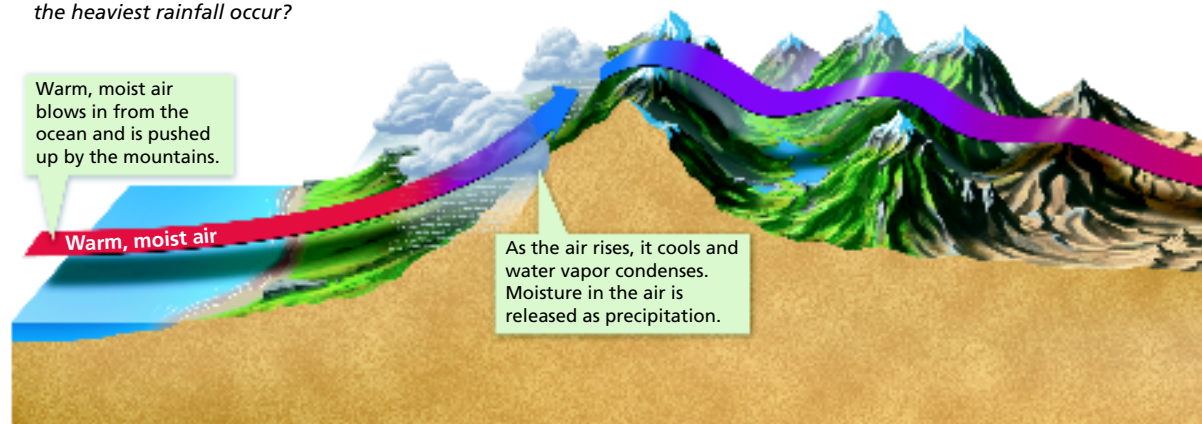
By the time the air has moved over the mountains, it has lost much of its water vapor, so it is cool and dry. The land on the **leeward** side of the mountains—downwind—is in a rain shadow. Little precipitation falls there.

FIGURE 4

Rain Shadow

A mountain range can form a barrier to the movement of humid air. Humid air cools as it is blown up the side of a mountain range.

Applying Concepts Where does the heaviest rainfall occur?



Inferring U.S. Precipitation Patterns

Materials physical map of the United States, map of global wind patterns, reference books

Time 20 minutes

Focus Review how topography affects precipitation patterns.

Teach Challenge small groups to work together and use only the maps to infer the amount of precipitation in different regions of the United States.

Apply Invite groups to share their inferences with the rest of the class. If groups disagree, have them check references to determine the correct answers and discuss why other inferences are incorrect.

learning modality: visual

Address Misconceptions L1

Monsoons

Focus Ask students to describe a monsoon. Most students will describe a period of torrential rain.

Teach Point out to students that monsoons are changes in the direction of regional winds. When winds blow from the water, more rain does occur. However, a dry monsoon season occurs when winds blow from the land.

Apply Direct students' attention to maps in Figure 5. Ask: **Which of the monsoons shown would most likely be a dry monsoon?** (*The winter monsoon*)

learning modality: logical/mathematical

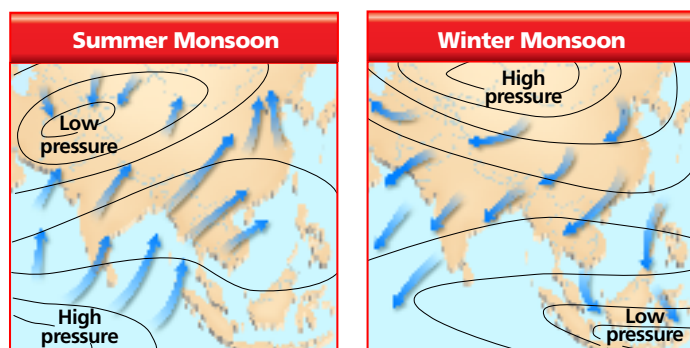


FIGURE 5
Monsoons

In a summer monsoon, wind blows from the ocean to the land. In the winter, the monsoon reverses and blows from the land to the ocean. Summer monsoons in Nepal cause heavy rain (above).

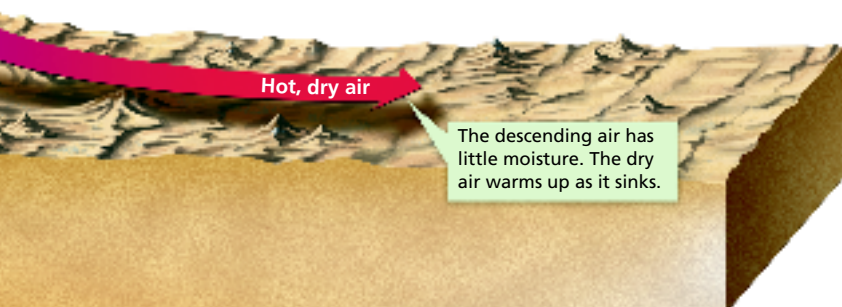
Seasonal Winds A seasonal change in wind patterns can affect precipitation. These seasonal winds are similar to land and sea breezes, but occur over a wider area. Sea and land breezes over a large region that change direction with the seasons are called **monsoons**. What produces a monsoon? In the summer in South and Southeast Asia, the land gradually gets warmer than the ocean. A “sea breeze” blows steadily inland from the ocean all summer, even at night. The air blowing from the ocean during this season is very warm and humid. As the humid air rises over the land, the air cools. This causes water vapor to condense into clouds, producing heavy rains.

Thailand and parts of India receive much of their rain from the summer monsoons. These rains supply the water needed by rice and other crops. Monsoon winds also bring rain to coastal areas in West Africa and northeastern South America.

Regions affected by monsoon winds receive very little rain in winter. In the winter, the land cools and becomes colder than the ocean. A “land breeze” blows steadily from the land to the ocean. These winds carry little moisture.



Why does precipitation fall mainly on the windward sides of mountains?



Differentiated Instruction

English Learners/Beginning L1
Vocabulary: Link to Visual Explain that *lee* means “shelter,” and point to the leeward side of the mountain in the figure on this page. *Windward* refers to the side of the mountain that is struck by the wind. Point to the windward side. Have students use the diagram as a guide for making their own diagram with labels of the

leeward and windward sides. **learning modality: visual**

English Learners/Intermediate L2
Vocabulary: Link to Visual Have students continue the activity above by writing short paragraphs describing the leeward and windward sides of a mountain range.

Monitor Progress L2

Skills Check Have students compare and contrast the two monsoon seasons.

Answers

Figure 4 The windward side



Air moving up mountains cools as it rises. The water vapor condenses and falls as rain or snow. The air on the leeward side has little moisture left.

The Seasons

Teach Key Concepts

L2

What Causes the Seasons

Focus Ask: Why can a person become sunburned so quickly at noon on a summer day? (*The sun is high in the sky. Its light shines down at a more direct angle and so is more concentrated.*)

Teach Tell students that the sun's light shines down at a more direct angle during summer than in winter. Explain how Earth's tilted axis causes different parts of Earth to receive different amounts of sunlight as Earth revolves around the sun.

Apply Ask: Does a flashlight look brighter when it's shone directly into your eyes or when it's shone toward you at an angle? (*Directly into the eyes*) Why? (*More light hits the area of your eyes*) **learning modality: verbal**

All in One Teaching Resources

- [Transparency 142](#)

Math Skills

Math Skill Percentage

Focus Draw a large circle on the board to show 360 degrees. Divide the circle into fourths to show 90-degree angles.

Teach Have students set up the fraction by writing $23.5/90$. Within one of the 90-degree angles that you drew, draw another line close to the 90-degree ray that shows what an angle of 23.5° would look like.

Answer

It is about 26.1 percent of a right angle.

Math Skills

Percentage Light from the sun strikes Earth's surface at different angles. An angle is made up of two lines that meet at a point. Angles are measured in degrees. A full circle has 360 degrees.

When the sun is directly overhead near the equator, it is at an angle of 90° to Earth's surface. A 90° angle is called a right angle. What percentage of a circle is it?

$$\frac{90 \text{ degrees}}{360 \text{ degrees}} = \frac{d\%}{100\%}$$

$$90 \times 100 = 360 \times d$$

$$\frac{90 \times 100}{360} = d = 25$$

A 90° angle is 25 percent of a full circle.

Practice Problem Earth's axis is tilted at an angle of 23.5° . About what percentage of a right angle is this?

FIGURE 6

Summer and Winter

There can be a striking difference between summer and winter in the same location. **Inferring**

During which season does the area shown receive more solar energy?



The Seasons

Although you can describe the average weather conditions of a climate region, these conditions are not constant all year long. Instead, most places outside the tropics have four seasons: winter, spring, summer, and autumn. When it is summer in the Northern Hemisphere it is winter in the Southern Hemisphere. So the seasons are not a result of changes in the distance between Earth and the sun. In fact, Earth is farthest from the sun during the summer in the Northern Hemisphere.

Tilted Axis The seasons are caused by the tilt of Earth's axis as Earth travels around the sun. The axis is an imaginary line through Earth's center that passes through both poles. Earth rotates, or turns, around this axis once each day. Earth's axis is not straight up and down, but is tilted at an angle of 23.5° . As Earth travels around the sun, its axis always points in the same direction. So the north end of the axis is pointed away from the sun for one part of the year and toward the sun for another part of the year.

Effect of the Tilted Axis Look at Figure 7. Which way is the north end of Earth's axis tilted in June? Notice that the Northern Hemisphere receives more direct rays from the sun. Also, in June the days in the Northern Hemisphere are longer than the nights. The combination of more direct rays and longer days makes Earth's surface warmer in the Northern Hemisphere than at any other time of the year. It is summer in the Northern Hemisphere. At the same time, the Southern Hemisphere is experiencing winter.

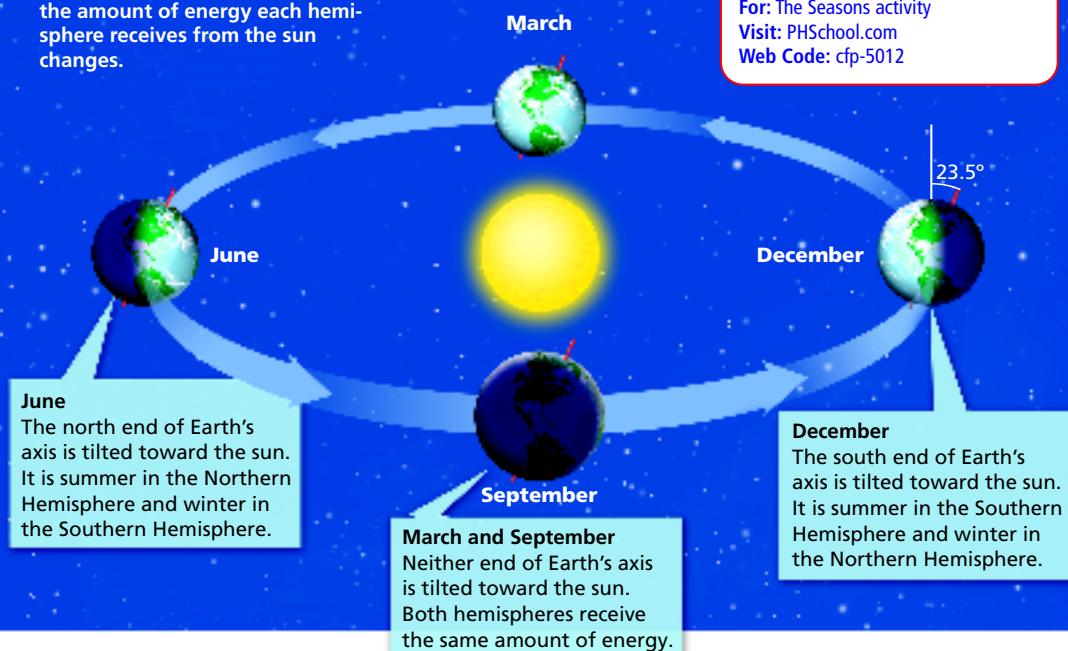
In December, on the other hand, the north end of Earth's axis is tilted away from the sun. It is winter in the Northern Hemisphere and summer in the Southern Hemisphere.



In June, what season is it in the Southern Hemisphere?

FIGURE 7
The Seasons

The seasons are a result of Earth's tilted axis. The seasons change as the amount of energy each hemisphere receives from the sun changes.



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Monitor Progress L2

Answers

Figure 6 Summer



Winter

Assess

Reviewing Key Concepts

1. a. Latitude, altitude, distance from large bodies of water, and ocean currents **b.** In general, temperature becomes lower toward the poles. **c.** The location in the middle of a continent will have a more extreme climate with cold winters and hot summers. The location near the coast will have warm summers and mild winters.

2. a. Prevailing winds, mountain ranges, and seasonal winds **b.** Prevailing winds might bring moist air masses or dry air masses to a region. **c.** There is likely to be a great deal of precipitation on the windward side of the mountain and little precipitation on the leeward side.

3. a. The tilt of Earth's axis as Earth revolves around the sun **b.** When the north end of Earth's axis points toward the sun, the Northern Hemisphere receives sunlight at a more direct angle and has more hours of daylight. It is summer. During the Northern Hemisphere winter, sunlight strikes the Northern Hemisphere less directly and there are fewer hours of daylight. **c.** There would be no seasons, so climates would not vary over the course of a year.

Reteach L1

Have students list and explain factors that affect temperature and precipitation.

Section 1 Assessment

Target Reading Skill Building Vocabulary
Use your sentences to help answer the questions.

Reviewing Key Concepts

- a. Identifying** Name four factors that affect temperature.

b. Describing How does temperature vary in Earth's temperature zones?

c. Comparing and Contrasting Two locations are at the same latitude in the temperate zone. One is in the middle of a continent. The other is on a coast affected by a warm ocean current. How will their climates differ?
- a. Listing** List three factors that affect precipitation.

b. Summarizing How do prevailing winds affect the amount of precipitation an area receives?

- c. Relating Cause and Effect** How does a mountain range in the path of prevailing winds affect precipitation on either side of the mountains?
- a. Reviewing** What causes the seasons?

b. Describing Describe the changes in Earth's orbit around the sun that cause the seasons.

c. Developing Hypotheses How might Earth's climates be different if Earth were not tilted on its axis?

Math Practice

- 4. Percentage** At noon at a particular location, the sun makes an angle of 66.5° with Earth's surface. What percentage of a full circle is this?

Math Practice

Math Skill Percentage

Answer

4. $(66.5/360) \times 100 \approx 18\%$

Lab zone Chapter Project

Keep Students on Track Meet with each group, and review the chosen sites. If they have chosen a site on private property, make sure that students have permission to study the site. Advise students to write their hypotheses about how the conditions of their sites will differ, and remind them to set up their logbooks. Emphasize the importance of taking measurements at the same time each day.

All in One Teaching Resources

- [Section Summary: What Causes Climate?](#)
- [Review and Reinforce: What Causes Climate?](#)
- [Enrich: What Causes Climate?](#)

Sunny Rays and Angles

Prepare for Inquiry

Key Concept

The angle at which the sun's rays strike Earth affects the amount of energy absorbed by Earth's surface.

Skills Objectives

Students will be able to

- design an experiment to show how a heat source affects temperatures under various conditions
- control variables to observe the effect of angles, distance, and time on temperature
- graph temperature data that they have collected
- infer which thermometer or temperature probe represents certain regions of Earth's surface



 **Prep Time** 15 minutes

Class Time 40 minutes

Advance Planning

You might want to make the construction paper pockets for students ahead of time.

Safety

  Caution students to be careful when handling the lamp. Point out that the lightbulb and the lampshade get hot. Remind students to use care when using scissors. Review the safety guidelines in Appendix A.

All in One Teaching Resources

- [Lab Worksheet: Sunny Rays and Angles](#)

Guide Inquiry

Invitation

Remind students of their results from the Discover Activity. Ask: **On what part of Earth's surface do the sun's rays hit straight on?** (*At the equator*) **Where do the rays hit Earth at the smallest angle?** (*At the poles*)

Sunny Rays and Angles

Problem

How does the angle of a light source affect the rate at which the temperature of a surface changes?

Skills Focus

controlling variables, graphing, interpreting data, making models


Materials

- books • graph paper • pencil
- watch or clock • ruler • clear tape
- 3 thermometers or temperature probes
- protractor • 100-W incandescent lamp
- scissors • black construction paper

Procedure

1. Cut a strip of black construction paper 5 cm by 10 cm. Fold the paper in half and tape two sides to form a pocket.
2. Repeat Step 1 to make two more pockets.

Data Table			
Time (min.)	Temperature (°C)		
	0° Angle	45° Angle	90° Angle
Start			
1			
2			
3			
4			
5			

3.  Place the bulb of a thermometer inside each pocket. If you're using a temperature probe, see your teacher for instructions.
4. Place the pockets with thermometers close together, as shown in the photo. Place one thermometer in a vertical position (90° angle), one at a 45° angle, and the third one in a horizontal position (0° angle). Use a protractor to measure the angles. Support the thermometers with books.
5. Position the lamp so that it is 30 cm from each of the thermometer bulbs. Make sure the lamp will not move during the activity.
6. Copy a data table like the one above into your notebook.

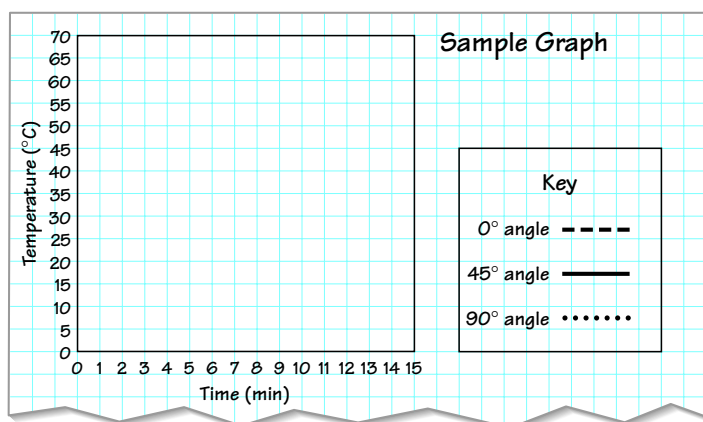


Introduce the Procedure

Have students read the procedure. Ask: **What part of the setup represents the sun?** (*The lamp*) **Earth's surface?** (*The paper pockets*) Point out how the books are used to hold the thermometers at a 45-degree angle and at a 90-degree angle. Demonstrate how to use the protractor.

Troubleshooting the Experiment

- Show students one completed thermometer pocket as a model.
- Advise students to place all three of the thermometer bulbs near one another so that each one is the same distance from the lamp.
- Remind students to record the temperature from each thermometer before they turn on the lamp.



7. In your data table, record the temperature on all three thermometers. (All three temperatures should be the same.)
8. Switch on the lamp. In your data table, record the temperature on each thermometer every minute for 15 minutes. **CAUTION:** Be careful not to touch the hot lampshade.
9. After 15 minutes, switch off the lamp.

Analyze and Conclude

1. **Controlling Variables** In this experiment, what was the manipulated variable? What was the responding variable?
2. **Graphing** Graph your data. Label the horizontal axis and vertical axis of your graph as shown on the sample graph. Use solid, dashed, and dotted lines to show the results from each thermometer, as shown in the key.
3. **Interpreting Data** Based on your data, at which angle did the temperature increase the most?

4. **Interpreting Data** At which angle did the temperature increase the least?
5. **Making Models** What part of Earth's surface does each thermometer represent?
6. **Drawing Conclusions** Why is air at the North Pole still very cold in the summer even though the Northern Hemisphere is tilted toward the sun?
7. **Communicating** Write a paragraph explaining what variables were held constant in this experiment.

Design an Experiment

Design an experiment to find out how the results of the investigation would change if the lamp were placed farther from the thermometers. Then, design another experiment to find out what happened if the lamp were placed closer to the thermometers.

Expected Outcome

The thermometer at the 0° angle will show the highest increase in temperature, the thermometer at the 90° angle the lowest, and the thermometer at the 45° angle a moderate increase. Moving the lamp closer to the thermometers will increase the temperature readings, and moving it farther away will decrease the temperature readings. The longer the lamp shines on the thermometers, the higher the temperature readings will be, until an equilibrium value is reached.

Analyze and Conclude

1. Manipulated: Angle of the thermometer. Responding: Rate of temperature change.
2. All three lines of the graph should show an increase in temperature over time. The line for the thermometer at 0° should show a greater temperature increase than the line for the thermometer at 45°, which should show a greater temperature increase than the line for the thermometer at 90°.
3. At the 0° angle
4. At the 90° angle
5. The thermometer at 0° represents the equator, or tropical zone, the thermometer at 45° the temperate zone, and the thermometer at 90° the poles, or polar zone.
6. The angle at which the sun's rays strike the North Pole in summer is still very small.
7. Variables that were held constant included the thermometers, the heat source, the distance of the heat source from the thermometer bulbs, the time, and the type of heat-absorbing material.

Extend Inquiry

More to Explore With all the pockets at the same angle and exposed to light for the same time, test distance.